

Intraoperative Management of Robotic-Assisted Versus Open Radical Prostatectomy

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ABSTRACT

Background and Objectives: Minimally invasive surgery has been shown to decrease postoperative morbidity and length of stay for several laparoscopic procedures. We sought to retrospectively compare intraoperative surgical and anesthetic parameters, postanesthetic care unit (PACU) length of stay, and hospital length of stay of patients who underwent robotic-assisted laparoscopic radical prostatectomy (RAP) versus open radical retropubic prostatectomy (ORP).

Methods: A retrospective investigation was performed using a urologic surgery database and an anesthesia electronic medical record. We queried information regarding 106 ORP patients from 2002 through 2007 and 575 RAP patients from 2007 through 2008.

Results: Patients in the RAP group compared with ORP patients had reductions in surgical time, anesthesia time, estimated blood loss, crystalloid administration, and PACU and hospital length of stays. Compared with ORP procedures, intraoperative respiratory rates, peak inspiratory pressures, and arterial pressures in RAP procedures were higher; tidal volumes and heart rates were decreased; but end-tidal carbon dioxide concentrations were not different. In the RAP group, intraoperative complications included severe bradycardia, corneal abrasions, and 2 patients required reintubation. Surgically, no rectal perforations were noted, and no operative mortalities occurred.

Conclusions: Our data demonstrate the safety and efficacy of RAP due to a combination of surgical and anesthetic factors.

Key Words: Robotic-assisted prostatectomy, Radical prostatectomy, Prostate cancer, Anesthesia.

INTRODUCTION

Robotic-assisted laparoscopic radical retropubic prostatectomy (RAP) is a technique that has gained popularity among urologists, gradually supplanting the traditional open radical retropubic prostatectomy (ORP)¹ for the treatment of prostate cancer. The intraoperative management of robotic procedures creates both advantages and challenges that have been previously reported. Specifically, reduced blood² and fluid requirements, decreased recovery time, and hospital length of stay are major advantages. The challenges that arise include airway edema related to the steep Trendelenburg position, brachial plexus injuries, and corneal abrasions.³⁻⁹

The change in practice pattern at the authors' institution (where the use of the robotic approach is now prevalent) has created an opportunity for a review of the surgical and anesthetic databases. The authors hypothesized that intraoperative surgical parameters, hemodynamic stability, blood and fluid requirements, and postanesthesia care unit length of stay would be improved with the robotic approach. Additionally, we hypothesized that our hospital length of stay data would show a similar pattern to that in previous reports.

MATERIALS AND METHODS

Prior to 2007, radical retropubic prostatectomies (ORP) were typically performed in our center by one of several experienced urologic surgeons using an open surgical technique. Since 2007, with the addition of a robotically trained urologic surgeon, all of the robotic-assisted laparoscopic prostatectomies (RAP) in this study have been performed by one surgeon.

With Institutional Review Board approval for a retrospective investigation and waiver of informed consent, we queried our anesthesia electronic medical record (CompuRecord, Philips Medical Systems, Andover, MA) as well

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as a dedicated urologic surgery database to identify radical prostatectomy cases performed using 1 of the 2 techniques. Cases involving combined procedures (eg, radical cystectomy) or laparoscopy without robotic assistance were excluded. For each included case, perioperative parameters of interest were extracted as listed in **Table 1**.

Statistical Analysis

For parameters that were available throughout the study period for both surgical technique groups, the

average of each continuous variable was calculated in each case individually. To account for the non-normal distribution of the average values for physiological parameters within the groups, the Mann-Whitney test was used to test for differences in median values between the open and robotic groups, with a 2-tailed $P < 0.05$ required for statistical significance. For frequency data, the Fisher exact test was used to test for the presence of statistically significant differences. Data are presented as the median [range].

Table 1.
Median [range] of Values of Select Parameters for Radical Retropubic Prostatectomies

	Open Technique (ORP) (n=106)	Robotic-Assisted Laparoscopic Technique (RAP) (n=575)	P*
Time Period	2002–2007	2007–2008	
Age (yrs)	61 [42–84]	60 [41–79]	0.23
Body Mass Index	27 [16–39]	27 [19–41]	0.74
ASA Classification	2 [1–3]	2 [1–3]	0.93
Preop Hematocrit (%)	42 [22–50]	44 [30–52]	<0.01
Total Case Time (min)	318 [179–592]	174 [112–380]	<0.01
Surgical Time (min)	243 [125–480]	119 [60–270]	<0.01
Estimated Blood Loss (mL)	1200 [250–5000]	50 [5–400]	<0.01
Crystalloid (mL)	5000 [2000–9300]	1600 [500–3300]	<0.01
Allogeneic RBCs (mL; % of cases)	0 [0–1250]; 27	0 [0–0]; 0	<0.01 <0.01
Cell Salvage (mL)	500 [0–3000]	0 [0–0]	<0.01
Cell Salvage (% of cases)	82	0	<0.01
Average Tidal Volume (mL)	707 [465–989]	652 [420–917]	<0.01
Average Respiratory Rate (per min)	9 [6–22]	11 [8–19]	<0.01
Average EtCO ₂ (mmHg)	31 [26–50]	31 [25–44]	0.37
Average Peak Inspiratory Pressure (cmH ₂ O)	21 [11–33]	29 [15–45]	<0.01
Average Peak Inspiratory Pressure >30 cmH ₂ O (%)	2	37	<0.01
Average Heart Rate (per min)	68 [49–90]	64 [42–90]	<0.01
Average Mean Arterial Pressure (mmHg)	80 [63–99]	87 [62–111]	<0.01
Average Core Temperature (°C)	36.3 [33.9–37.3]	36.2 [34.0–37.3]	0.46
Average SpO ₂ (%)	99 [96–99]	98 [92–100]	<0.01
Extubation (% of cases)	98	99	0.17
PACU Length of Stay (min)	237 [118–665]	167 [56–1392]	0.04
Hospital Length of Stay (days)	3 [2–5]	1 [1–15]	<0.01

* Mann-Whitney or Fisher exact test.

RESULTS

The results of 106 ORP and 575 RAP are summarized in **Table 1**. No difference existed in the baseline demographic data between the 2 groups of patients. Compared with open procedures, robotically assisted procedures were associated with 45% shorter median anesthesia time, 51% shorter surgical time, 96% less estimated blood loss, 68% less crystalloid administration intraoperatively, and no cases where intraoperative allogeneic transfusion or intraoperative red cell salvaging were required (**Table 1**).

Compared with open procedures, in robotic procedures intraoperative respiratory parameters demonstrated that robotic procedures were associated with 8% lower tidal volume, a 22% increase in respiratory rate, a 38% increase in peak inspiratory pressures, but identical end-tidal carbon dioxide concentrations. Digital pulse oximetry was statistically reduced in robotically assisted cases, but the lowest recorded SpO₂ was 92% in the entire series.

Compared with open procedures, intraoperative hemodynamics showed higher mean arterial pressures (MAP) and lower heart (HR) rates in the robotically assisted cases. Core temperatures and likelihood of extubation at the end of the procedure were not statistically different. Median PACU length of stay was decreased by 30% in patients who underwent the robotically assisted procedure, and the hospital length of stay was also decreased by 67% in comparison with the open procedures.

Intraoperative complications in the RAP group included severe bradycardia (heart rate <40 per min) in 7 patients upon insufflation. One patient became asystolic and was treated by immediately releasing the intraperitoneal gas, chest compressions, and pharmacological intervention with prompt resolution. The other patients were treated with pharmacological intervention only. Initially, corneal abrasions occurred in several patients undergoing the RAP procedure, but with a change in procedure from taping the eyes closed to using a transparent occlusive dressing, this complication has not recurred.

None of the RAP cases were converted to open procedures, and no deaths occurred in either group. None of the RAP patients required reintubation secondary to laryngeal edema caused by use of the steep Trendelenburg position, but 2 patients were reintubated because of decreased respiratory drive. Also, there were no occurrences of brachial plexus injuries in the RAP group.

Surgically, there were no rectal perforations or any other intraoperative complications in the RAP group. Postoper-

atively, there were 4 pelvic collections requiring drainage, 3 pulmonary emboli, 2 deep venous thromboses, 4 urinary retentions, 3 prolonged hematurias, 2 ileus (requiring extended hospital stay or readmission), 1 port-site hernia, 1 bowel obstruction, 1 bowel injury (in a patient with prior extensive bowel surgery), 1 lymphocele, 1 epididymo-orchitis, 1 pelvic hematoma requiring transfusion, 1 JP site hemorrhage requiring transfusion, 1 wound infection, and 1 urethro-vesical anastomotic leak. No comprehensive database exists of complications for the ORP patients.

DISCUSSION

In this retrospective, single-institution, cohort analysis, we have demonstrated that RAP is associated with shorter operative times, less blood loss, reduced recovery time and hospital length of stay compared with traditional ORP. The choice to perform RAP is made solely by the urologic surgeon, but this choice has major implications for the intraoperative course that are reflected in anesthetic as well as surgical parameters and outcomes. Others have cited the special coordination between surgeon and anesthesiologist that is required for a successful RAP program due to the modified laparoscopic technique and steep Trendelenburg position.^{10,11}

The anesthetic issues related to exaggerated lithotomy and steep Trendelenburg positions include effects on respiratory system mechanics and arterial oxygenation, and the need for careful monitoring in pelvic reconstructive procedures.^{12–14} The primary intraoperative anesthetic concern during ORP is the management of blood and fluid requirements, whereas during RAP it is the management of the patient with pneumoperitoneum in the steep Trendelenburg position.

Several authors^{3,9,15–18} have reported on physiological effects of pneumoperitoneum in the Trendelenburg position. These reports differ from the current one in that the hemodynamic observations were made by comparing patients with their baseline anesthetized state before and after placement in the Trendelenburg position. The current report compared hemodynamics over the entire surgical period between 2 groups of patients (either having ORP or RAP). The differences in study design may have influenced the findings.

While most studies^{9,15–18} including the current one found an increase in MAP, one study reported a decrease of 17%.³ Changes in HR have been variably reported, with increased HR,¹⁵ no change in HR,⁹ and decreased HR.³ The current study found a 6% decrease in HR. Unlike the

current study, however, the previous reports are very likely to have derived the hemodynamic data from hand-written anesthesia records, in which the data have been shown to be unreliable.¹⁹ While these changes are statistically significant, their clinical significance is minimal.

Trendelenburg position and pneumoperitoneum for RAP also impair respiratory mechanics. Decreases in pulmonary compliance and tidal volumes along with increases in peak and plateau airway pressures have been reported.^{3,15} To overcome the effects of elevated intraabdominal pressure and the cephalad shift of the diaphragm, an elevated peak airway pressure is necessary to maintain a constant minute volume.¹⁵ However, the extent to which the elevated intrathoracic pressure ameliorates the actual transmural pressure at the alveolar level and the degree to which that attenuates any intraoperative barotrauma is unknown. In the current series, the RAP group (in comparison with the ORP group) had a 38% increase in the average peak inspiratory pressure; 37% of RAP patients had an average peak inspiratory pressure over 30 cm H₂O compared with only 2% of the ORP patients. This increase in peak inspiratory pressures in the RAP group was associated with an 8% decrease in tidal volumes and a 22% increase in the respiratory rate so as to minimize hypercarbia. Hypercarbia is accentuated by the absorption of carbon dioxide during pneumoperitoneum. Another concern is that with increased peak inspiratory pressures the risk of barotrauma is present. This risk can be lowered by reducing tidal volume, increasing respiratory rate and permissive hypercarbia.

Corneal abrasion has been reported as the most common anesthesia-related complication in RAP with an incidence of 3%.³ This incidence decreased to 1% with the adoption of eye patches for ocular protection. In the current series, we had several corneal abrasions in RAP cases associated with the use of eye tape, but with a change in procedure to using a transparent occlusive dressing over the eyes, this complication has not recurred.

Another uncommon complication in our series was severe bradycardia, which occurred with an incidence of 1%, in temporal association with insufflation in RAP cases. Previous studies in patients undergoing laparoscopic cholecystectomies have reported bradycardia in up to 4.7% of cases.²⁰ Currently, the cause is unknown, although it is likely related to vagal stimulation that is elicited by peritoneal distension and/or irritation by the carbon dioxide insufflation.

Another complication that has been reported in RAP procedures is the occurrence of laryngeal edema which ne-

cessitated reintubation.⁴ Pharyngeal, laryngeal, and facial edema have been associated with prolonged steep Trendelenburg positioning.¹ Fluid restriction not only can minimize the amount of facial and airway edema, but also can decrease excessive urine output that obscures the operative field during bladder neck and urethrovesical anastomoses.³ Our series of RAP patients received mildly restrictive fluid management and had short operative times. None of the patients in the RAP series required reintubation related to airway edema.

Careful positioning of the patient for RAP is of utmost concern. These patients are prone to sliding off the operating table during table position changes, especially in the steep (45°) Trendelenburg position.^{3,4} Shoulder braces have been implicated in causing brachial plexus injuries, and several authors^{3,4} have advocated the technique of strapping the patient to the operating table with chest binding in an "x" like pattern. The disadvantage of chest binding in patients being placed in a steep Trendelenburg position along with pneumoperitoneum is a further decrease in pulmonary compliance.³ In our institution, we use horseshoe-shaped shoulder braces on patients who weigh >75kg—carefully positioning them around the acromioclavicular joint. In our series, there have been no clinically apparent brachial plexus injuries.

The overall postoperative surgical complication rate in our series was 4.7%, which compares favorably with most contemporary open and laparoscopic series.^{21–23} Our surgical operative times and estimated blood loss figures were lower than those in previously reported series.^{3,6–8} The shorter hospital length of stay in patients undergoing RAP was similar to that at other institutions.^{7,8} We also found a significantly decreased PACU length of stay in RAP patients.

CONCLUSION

In the current report, RAP is a shorter operative procedure that is characterized by minimal blood loss, no intraoperative transfusions, reduced fluid requirements, and shorter PACU and hospital stays compared with traditional open procedures. Our data suggest that RAP might be a "less stressful" surgery for the patient than the traditional open surgery. The intraoperative management of the RAP patient in the steep Trendelenburg position with pneumoperitoneum presents manageable anesthetic challenges that are mainly related to ventilation and avoidance of positioning-related injuries. Although the relative long-term functional and oncological outcomes of robotic versus open procedures still require further investigation, the

intraoperative and hospital courses are markedly improved in the robotic cohort.²¹

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